REVIEWS.

Art. XXII.—*Ventilation of Hospitals.*

1. *Report of the Pennsylvania Hospital for the Insane.* 1874. By Thos. S. Kirkbride, M.D.
2. *On Hospitals.* By George Derby, M.D. (Fifth Annual Report of the State Board of Health of Massachusetts.)

This report, like all Dr. Kirkbride's, is interesting both to the friends of humanity and the friends of science. He takes this occasion to speak at some length on the subject of warming and ventilating hospitals. Presenting, as he does, the fruit of thirty years' observation and study, his conclusions are entitled to the highest respect and confidence. He reaffirms the conviction published twenty years ago in a treatise on the construction, etc., of hospitals for the insane, that an effectual ventilation of such establishments can be obtained only by means of some artificial motive power. The favour recently shown in some quarters to very different views, and set forth in the strongest manner by Dr. Derby, has led to this fresh declaration of his own, as warranted by the extreme importance of the subject; and for the same reason we have thought it worth our while to call the reader's attention very briefly to some of its most prominent aspects.

We doubt if any matter of sanitary science has been more ventilated than ventilation itself. In the transactions of every board of health, in the reports of every hospital for the insane, as well as those for bodily disease, in plans for new buildings more or less public, we can scarcely ever fail to find something respecting the importance of ventilation, and within the last twenty-five or thirty years, it has been made the theme of scores of special treatises. And yet, after all the speculation and experiment during that period, there remains a wide diversity of opinion as to the comparative value of the various methods proposed, while some are seriously asking if ventilation really does ventilate. At first blush this may seem strange, as the needs of air in respiration have been duly described by physiologists; its movements under various circumstances obey the laws of pneumatics; the volume and rapidity of its currents are easily calculated, and the happiest results have been often obtained in actual practice. Indeed, the very simplicity of the subject may have led to some of this diversity of views, because, as we well know, the easier, apparently, a matter is to understand, the more ready are those to pass in judgment upon it who lack the requisite knowledge. It is not strange, therefore, that to the uninstructed, anxiously desiring to learn the truth, the whole subject seems, to use a homely term, to be in a hopeless muddle. It may be worth our while, therefore, to review the situation—to show very briefly what progress has been made, and to see, as well as we can, where we now stand.

It is within the memory of the present generation that any special attention began to be given to the ventilation of hospitals. Up to that time, if it was supposed that they needed a more frequent change of air than was furnished to ordinary dwellings through the doors and windows, it was trusted to Providence, aided occasionally by a resort to chimney-tops, cowls, and turncaps. Some thirty-five or forty years ago, the idea occurred to a few thinking people that in order to maintain the sanitary condition of these establishments at the highest point, and thus enable them to fulfil their purpose in the best possible manner, they must be furnished with a more frequent change of air than was needed in a domestic residence. Unfortunately, this period happened to coincide with that when new methods of warming came into favour, no part of *their* purpose being to improve the ventilation. On the contrary, they had the opposite effect. The chimneys with their open fires, which had been the chief reliance, and which did really promote some change of air, were supposed to be no longer required in buildings warmed exclusively by direct radiation from pipes conveying steam or hot water. The effect on public opinion was manifested in a rule adopted by the governors of the Lincoln Asylum for the Insane, England, absolutely forbidding any attempt to warm the wards in any other way than by fires in the chimneys. But the new idea survived the perils encountered in its germination, and in various ways continued to show signs of life, until it became an active, efficient principle in the construction of hospitals, prisons, court-rooms, and other public buildings where large numbers of people congregate.

The project of furnishing hospitals a better ventilation implied the application of an artificial force that would effect a more frequent interchange of air than could be obtained by ordinary arrangements. To carry this purpose into effect required no discovery or invention, but simply the mechanical application of principles as well established as any in art or science, by means of contrivances better fitted for the purpose than any then in use. In the early part of the last century, Dr. Desaguliers, in order to ventilate the British Houses of Parliament, provided in the attic a chimney heated by a fire, into which the foul air entered through openings in the ceiling. At a later period, he introduced a centrifugal wheel or blowing fan, driven by a single labourer. In 1820 the Marquis de Chabaunes substituted for the fire in the chimney a number of cylinders filled with steam from a boiler below. Sir Humphrey Davy had previously provided for the admission of fresh air through a multitude of holes in the floor. These contrivances failed to secure the desired object in the highest degree, but long custom and a lack of that delicate sensibility to noxious impressions which is one of the results of modern refinement, led to such toleration of the defect, that any attempt at improvement was seldom thought of. When, however, the new Houses of Parliament were projected, it was determined that they should be warmed and ventilated in a manner most completely to reflect the science and mechanical skill of the time. Accordingly, Dr. Reid was employed to prosecute a course of experiments on the ventilation of the old houses, which ended in a systematic and elaborate arrangement, the efficiency of which was admitted by every reasonable person. Nothing of this kind so skilful, so thorough, and so effective, had ever been done before, although it was only an extension of existing principles by larger and better methods. About this time a large prison was built at Pentonville, near London, which was ventilated by means of a tall chimney starting from the ground, heated by a perpetual fire, into which all the foul-air flues were conducted. Thenceforth the indispensable need of a forced ventilation wherever many persons are associated together continuously for any considerable time, became a very common belief, even in this country. In 1845, the trustees of the Butler Hospital for the Insane, about to be erected in Providence, R. I., engaged Dr. Bell, then superintendent of the McLean Asylum in Somerville, Mass., to visit Europe, and learn whatever he could, worthy of imitation, in hospital construction, and especially in the matter of warming and ventilation. As the result of his inquiries, he recommended the method adopted in the Pentonville prison, using the kitchen chimney, however, rather than one built solely for this purpose.

Since then scarcely one of the many hospitals for the insane established in this country has been unprovided with a forced ventilation. In them the favourite instrument is the fan propelled by the steam-engine always used in them for one purpose or another. This forces the air over coils of steam pipe, heated in cold weather, up through flues in the walls into the various apartments. The power of the fan is sometimes supplemented by that of the waste heat of fires used for other purposes. Thus, in the department for males of the Pennsylvania Hospital for the Insane, while air is forced in by the fan in the usual way, flues connected with the water-closets convey their foul air downwards and across the lawn, under ground, into the tall chimney that is heated by the smoke made by the fires under the steam-boilers. And so strong is the force thus made, that a lighted paper thrown into the pan actually roars, as the flame is drawn downwards. In a ward recently erected on the female side of the same institution, the foul air passes up into the attic, and thence into a large brick flue heated by the smoke-stack which rises through it.

Notwithstanding this almost universal adoption of a forced ventilation by the hospitals for the insane, it is a curious fact that we find it in very few of our general hospitals. In those of Philadelphia, for instance, excellent as they are in every other respect—always excepting that connected with the almshouse, which never can be excellent until it is torn in pieces and made over again—one only, the Episcopal, is provided with what may be properly called a forced ventilation. In a pavilion of one story just erected for the Presbyterian Hospital, in West Philadelphia, the only provision for admitting fresh air, besides that of the doors and windows, is that of several openings in the walls, through which the air is brought directly from the outside, *whenever it is willing to come.* The openings in the roof through which the foul air is expected to escape, will, no doubt, admit considerably more, though that may not be very conducive to a steady ventilation. In the new hospital established by the University of Pennsylvania, the admitted air is warmed by passing over steam-coils in the basement, and the pipes conveying it pass up in the foul-air flues, and impart to them some of their heat. Several open fires in each ward, as in the Presbyterian Hospital, are supposed to supply some exhaustive force. Besides these sources of ventilating power, there is no other. We understand, however, that the present arrangement is merely experimental, to be changed for something better, if found to be unsatisfactory.

This disposition among men charged with hospital affairs to ignore the advances already made in the art of ventilation, or regard them as of little account, results, we are inclined to think, from very inadequate notions as to the amount of fresh air required for the best sanitary effect, and an imperfect acquaintance with what has been accomplished. It would seem to need no prophet to tell us that of all the buildings occupied by men or women, none require a more active ventilation than those devoted to the care of the sick. That the exhalations from their bodies, and especially from suppurating surfaces, contaminate the air, and to that degree render it unfit for respiration, nobody doubts. Nor is it denied that such emanations may adhere to the walls and floors and thus become a source of fresh disease. That apartments crowded with persons thus vitiating the air around them, require some special and larger means for renewing the air than would answer in an ordinary dwelling, would seem to be a foregone conclusion challenging universal assent. But exactly how much fresh air should be supplied to the inmates of a hospital is a point which has been decided too often by vague impressions rather than intelligent calculation. Apartments frequented by few people will get sufficient air through the doors and windows. Under ordinary conditions, a person of average size vitiates about twenty cubic feet of air in a minute. Now, to insure him his twenty feet against all adverse conditions, provision should be made for double that amount, and this is what is done in the Pentonville prison above alluded to. Substituting for the convicts of a prison the patients of a general hospital, double this amount, or eighty feet, would not be an unreasonable supply. Consequently a ward containing thirty patients would require 2400 cubic feet of air per minute, and this it must have to secure the best results of treatment. Now, can anybody suppose that by any possible arrangement depending solely on natural atmospherical conditions, even a tithe of that amount could be furnised steadily and continuously, night and day, summer and winter? With doors and windows wide open, and a stiff breeze blowing outside, we might, certainly dispense with every other means, but for how many days in the year, or portions of a day, do such conditions exist? For weeks together the windows must be closed, and for days together the air is still. No matter how many openings may be provided for the fresh air to come in, we know it will not come at those times when the temperature of the outside and that of the inside air are nearly equal.

It is a common impression that when provision is made for heating the air before it is introduced into the wards, the heat will impart to it a motion sufficient for the requisite ventilation. Considered as a system, it would be enough to say in regard to it that for a large part of the time the air is not heated at all. This method of ventilating by means of the force contained in the fresh heated air has been tried, and if the amplest experience is worth anything, its inefficiency at all times is proved beyond question. Some years ago, when State hospitals for the insane began to be established in this country, the common arrangement was to warm the fresh air in the basement by bringing it in contact with furnaces, from which it was conducted by flues in the walls to the various apartments, and from them the foul air ascended by another set of flues to the attic, and went off through windows in the roof or gables. At least such was the builder's programme, but practically it never fully accomplished the purpose. To some extent, certainly, the air was renewed by this arrangement, for the heated air which flowed in would necessarily displace an equal amount of air already used; but the interchange thus effected was not sufficient. The supply of fresh air was too small, and the ascensive motion imparted to it by the heat was not strong enough to overcome the outside pressure which forced the foul air back through many of the flues. Even this imperfect performance was not accomplished when the admitted air required no warming. True, the slight warming of the air effected by respiration would give it an upward motion; but the idea, if ever seriously entertained, that the amount of displacement thus produced could meet all the requirements of hospital ventilation, would only show how poorly the whole matter has been understood.

The failure of the method of ventilation here described, even when supplemented by turncaps, patent ventilators, *et id genus omne*, confirmed the impression derived from general principles and the examples abroad, that resort must be had to artificial force, and it has happened, as already stated, that it is now used, in some shape or another, in nearly all our hospitals for the insane. If such means are required in them, for a stronger reason they are required in general hospitals, where the air is so much more rapidly vitiated by active bodily disease, which is a comparatively insignificant element in the former.

And now, in the face of all this testimony, we are met by the objection that all these methods of forced ventilation have practically failed. In a paper published in the Fifth Annual Report of the Massachusetts State Board of Health, by the Secretary, the late Dr. Derby, whose decease in the maturity of his powers was a serious loss to sanitary science, he says: "All systems of supplying the needed amount of fresh air to hospitals of more than one story, have failed. The most elaborate artificial contrivances do not meet this fundamental want. From the Lariboisière at Paris, to the City Hospital at Boston, they are failures, one and all." It is to be regretted that the facts that served as the foundation of an opinion likely to have so much weight were not fully given, for thus only could its correctness be tested. We may safely say, however, that they would afford it but poor support, were they no stronger than the two which are mentioned. Two methods of ventilation are used in the Lariboisière Hospital. In some of the wards the motive power is a fan; in others it is a chimney heated by pipes filled with hot water—Duvoir's system, as it is called. A few years ago the French government appointed a commission to prepare plans for ventilating the new Palais de Justice, and to aid them in this duty they made a very elaborate investigation of the ventilation of this hospital. They reported that the two methods were about equally efficient, both furnishing from 2500 to 2700 cubic feet of air per bed per hour. The commission regards 3000 feet as the proper supply, and if still more be needed, an increase in the capacity of the means is all that is required. How a system of ventilation which supplies this amount of fresh air can be called a failure, we are unable to see. To us it seems like an eminent success; and so it seemed to the commission, for they recommended the adoption of the Duvoir system in the Palais de Justice. Some would favour a larger supply, but if all was obtained, be it much or little, which was wished or expected, then, certainly, it was no failure. In the Boston City Hospital a fan has been used, and we are told that the result has not been satisfactory. Why, exactly, we know not, but there are many conceivable, and many really existing, causes, to one or more of which it may be attributed, besides the inefficiency of the system. If in Paris a fan may be made to force into a building 2700 cubic feet of air per bed per hour, we presume that by observing the proper relations of size between the fan, the air ducts, and the building, it may be made to do the same thing in Boston. But there are some well-known facts in the history of that hospital during the first few years which will explain its defective ventilation without obliging us to blame the fan. In the first place, from motives of economy, the fan was used only a small part of the day. Then, frequent leaks in the soil pipes had contaminated the earth of the cellar. Some of the connections of these pipes with the drains were imperfect, so that sewer-gas escaped into the cellar. The fresh-air ducts, in their passage under the building, were not air-tight, and thus received sewer-gas from leaky drains and sewers. Under such circumstances, a fan with tenfold its capacity could not have given the wards pure air. Of course there was a good deal of pyæmia and erysipelas, but of which there was a marked abatement after these defects were corrected. Even without these defects the air supply would have been insufficient for lack of a proper proportion between the fan, the air-ducts, and the steam-coils.

This opinion of Dr. Derby we are unable to reconcile with his strong approval of the ventilation of the Warren Ward, lately erected at the Massachusetts General Hospital. In the last Report of that institution, he is quoted as saying (under date of April 5, 1874), after measuring the air currents several times, and finding the air supply equal to 7000 cubic feet per bed per hour, "on the whole it is the best ventilated hospital ward I ever saw." Now, this ward is warmed in a great degree by four Franklin stoves placed in its centre, and discharging their smoke into a common stack. Into a flue constructed around this stack, and warmed by it, open the foul-air flues, a powerful motion being given to their contents by the rarefaction thus produced. Stronger testimony than this in favour of artificial ventilation can scarcely be found. Had his observations been made on some day when there were no fires in the stoves, and the windows closed, he would have found the ventilation, probably, much less satisfactory. This suspicion is confirmed by the suggestion of the superintendent, Dr. Folsom, that in the summer when fires in the ward are not needed to warm the patients, the chimneys should be heated by fires below the floor, in the basement or cellar. This arrangement he has actually made in his plans for warming and ventilating the Johns Hopkins Hospital in Baltimore.

That attempts to ventilate by means of artificial force have sometimes failed we freely admit. Considering the comparative newness of the art, it is not strange that the mechanical appliances required should have been managed occasionally without a very strict compliance with the principles of natural philosophy. We have seen a central chimney for receiving the foul air too short even for the draught required by the fires under the boilers. We have seen steam coils placed in the cupola to which the foul air arose, quite inadequate to exert much extractive force, and so poorly put together that their incessant leaking made them a nuisance. We have seen a fan whose capacity for work obviously fell far short of the duty required. All this indicates only a lack of mechanical skill, not any fault in the principle. We have yet to learn the first instance of failure where the arrangements have been correctly made; and these are not a matter of magic or mystery, but simply of that knowledge of the properties of air which any high-school pupil may be supposed to acquire, of the requirements of respiration, and of an exact calculation of the force of the moving power and of the relations between the flues of ingress and those of egress.

Another source of distrust in regard to forced ventilation is a misconception of its legitimate results. More is apt to be expected than is possible in the nature of things. By no device of learning or of mechanical skill can the air of a hospital ward be made absolutely pure. Dr. Hammond very justly says, " It is rarely the case that the wards of a hospital can, by any system of ventilation, be so free from carbonic acid, aqueous vapour, and organic emanations, that the contained atmosphere will be identical in composition with that of the outside of the building. It is too much to expect this." (*Treatise on Hygiene*, p. 425.) Where, for instance, a patient has smeared the floors and walls of his room with his own excrement, a whirlwind blowing through it, even after the most thorough cleansing, would not for many hours deprive it entirely of bad odours. Let it ever be borne in mind that ventilation is a poor substitute for cleanliness, and whenever we hear the former condemned we like to know if the fault were not in the latter.

Judgments respecting the efficiency of a hospital ventilation are often prematurely formed after a hasty inspection, instead of a deliberate examination under different circumstances. The first and perhaps the only disagreeable odour that meets the olfactories is apt to be accepted as conclusive proof of a failure. It might have been a casual, accidental incident arising from some unusual cause. Occasions are frequently occurring where the performance of the necessary service may leave behind for a few minutes something perceptible to the senses. We believe the cry of failure would not have been so often heard if those who raised it had more wisely apprehended the limits of the ventilating art. Unless we have some definite idea of what it can and what it cannot accomplish, our estimate of the measure of its success in any actual case is liable to mistake. If it be a failure to provide at the same moment an amount of air and warmth equally satisfactory to a large, corpulent, sanguine individual, and one meagre, languid, and dyspeptic; to one just refreshed by a ride and a mutton-chop, with a glass or two of sherry, and another who has been sitting quietly the whole morning; to one who has accustomed himself to all sorts of weather, and another morbidly afraid of draughts; to the officers and attendants of a hospital, rejoicing in the glow of health, and the patients wasting away by disease—then, no doubt, forced ventilation has sometimes proved a failure.

Another reason offered for distrusting forced ventilation is the fact that its friends disagree respecting the relative merits of the various methods in use. We do not dispute the premise, but we cannot accept the conclusion. If we should maintain that sewing machines are just a delusion and a snare because their respective friends claim for each superior excellence, or contend that vaccination should be abandoned because it sometimes fails to afford that security which has been claimed for it, we should be guilty of logic about as absurd as that. Where different methods are used for obtaining the same end, all with some degree of success, it is not strange that opinions differ as to their relative efficiency. The circumstances under which they act, the mode of their application, the opportunities for observing results, all may differ and thus obscure for awhile the question of relative success. Disagreement may be a sure step in the course of inquiry, for it leads to fresh research, and thence to improvement. To reject a good thing altogether because people differ as to its exact value, is generally prompted by a spirit of indolence rather than by a healthy scepticism.

We have heard the expense of a forced ventilation given as a reason for its omission by some who are obliged reluctantly to acknowledge its success. General hospitals, it is said, have very limited means; they are dependent on the charity of the public, and must, therefore, observe the utmost frugality in all their arrangements. . And this excuse is offered in cases where there would seem to have been no stinted outlay for every other purpose, not even that of architectural decoration. Like most good things, good ventilation, unquestionably, costs money; and if it is necessary to the best hygienic condition, as we believe it is, then it must be had regardless of expense. When we undertake to put the patients on a stinted allowance of food and medicine in order to save expense, we may talk of stinting their supply of fresh air, but not before. In fact, however, the cost of maintaining a forced ventilation in general hospitals is much less than one might infer from this excuse. A commission that examined the ventilation of the Parisian hospitals a few years ago, reported that the annual cost per bed varied from six dollars and seventy-five cents to about triple that amount. In the Pentonville Prison the ventilation was found to cost from a quarter to half a farthing per cell per day. In this country, where fuel is so much cheaper than in France, the cost would be much less; and wherever steam is employed for warming and domestic purposes, the additional amount required for running a fan or heating a chimney would make but a small item in the expenditures of the establishment.

To write about hospital ventilation without adverting to the one-story pavilions that have come into such sudden favor, would seem like acting the play with Hamlet left out. One of the advantages claimed for them is that of a better ventilation than is possible in buildings of two or three stories. Under what rule or principle of natural philosophy this could be expected, we are unable to see. It has arisen, probably, from the vulgar error of confounding quantity with quality, and supposing that if a patient has plenty of space, we need not concern ourselves about the qualities of the air. And yet, we never heard of a person fearlessly exposing himself to marsh miasmata, in the belief that having the whole heavens above and around him, he would be perfectly safe. Whether with a natural or forced ventilation, a large space overhead can lend no aid in renewing the air. For, of course, the larger the amount of air to be changed, the more active and powerful must be the agency employed in producing the change. Any deficiency here implies a lack of that steady movement of the air which marks a good ventilation, and also induces counter currents in all directions. Ridge ventilation, as it is called, must, under the most favourable circumstances, be disturbed by wind and rain and snow; and whoever supposes that the frequent closing and opening of valves and louvre boards required to meet these incidents will be properly attended to, can have no practical acquaintance with nurses and attendants.

In the arrangements for warming and ventilating the new one-story ward at the Presbyterian Hospital, in West Philadelphia, all notions on this subject, hitherto considered as settled, have been utterly discarded. The ward is warmed by direct radiation from hot-water pipes that run along the walls near the floor. The fresh air is admitted directly from the outside through holes in the walls below the level of the beds, and, of course, cold in cold weather. When more is required, resort is had to open windows. The foul air is supposed to find its way out through the openings in the ridge. No effort of ingenuity can prevent the fresh air from entering some of these openings, and thus producing a general mixture of foul air and fresh air. The ventilation is supposed to be promoted by four fire-places, as it undoubtedly will be, in a small degree, while there is fire in them. The water-closets are supposed to be ventilated through the windows when left open. As if to increase the expense of warming, the space between the floor and the ground, corresponding to the cellar, is swept by the winds of heaven through many large openings in the walls.

Precisely what form the supplementary force should take must depend, in a great degree, on the circumstances of each particular case. The most economical, certainly, is that of a tall chimney heated by the smoke and gases of the fires used in the house, into which the foul air is discharged, and the hotter and higher it is made, the greater will be its power. This has the advantage of utilizing heat that would otherwise be wasted, of being constantly in operation, and of requiring no additional attendance. Where steam is not used, the kitchen chimney may, generally, be so contrived as to do the work, and if it prove insufficient for the purpose, additional heat can easily be provided. To examine the various ways of adapting these general methods to actual practice, forms no part of our present purpose. This is the business of the architect and builder aided by the results of scientific investigation, and profiting by experiments already tried. We have cared only to meet the pressing necessity of the time, that of re-affirming the great fundamental truth—as well established, certainly, as any truth can be, by principle and practice, though strangely ignored just now—that a ventilation forced by some artificial means is absolutely necessary to the highest sanitary condition of a general hospital. I. R.

ART. XXIII.—*Researches into the Antagonism of Medicines; being the Report of the Edinburgh Committee of the British Medical Association.* By JOHN HUGHES BENNETT, M.D., F.R.S.E., Hon. Fellow of the King's and Queen's Coll. of Phys. in Ireland, etc., Chairman and Reporter. 8vo. pp. 100. London: J. & A. Churchill, 1875.

THIS handsome brochure of a hundred pages is a reprint from the *British Medical Journal*, in which the Report originally appeared, and where it has doubtless been perused by many of our readers. A brief abstract of its contents has already been given in the "Quarterly Summary" of the *American Journal of the Medical Sciences* for January and April, 1875, so far as the results of the experiments had been then reported. We embrace the present occasion for a rather more extended notice.

In his opening article, Dr. Bennett alludes to his former Report to the British Association, made in 1868, "On the Action of Mercury on the Biliary System," and he thinks that the results of his investigations at that time "finally settled the long disputed subject, and demonstrated, beyond the possibility of reasonable objection, that in this respect mercury has none of the properties that have so long been attributed to it."

We do not propose to open this question at present. We have not forgotten the stir that this announcement made in the profession at the time. We remember that many were disposed to yield up their long-cherished convictions on this point to this eminent authority; whilst many others—and we apprehend their number has not diminished—still declined to relinquish the use of a remedy of whose value they believed they had witnessed the most ample proofs.